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ABSTRACT

This investigation was designed to ascertain whether students could transfer concepts related to specific rules of conditional logic to two designated areas. Specifically, the first type of transfer investigated was concerned with the ability of students to judge verbal simple deductive arguments written with suggestive content after instruction on judging the same types of arguments written with nonsuggestive content. The types of arguments used in this test of transfer dealt with the contrapositive, converse, and transitive principles of conditional logic. The second type of transfer investigated was the ability of students to judge verbal simple deductive arguments written with familiar content which were examples of the principle of inversion, after instruction only on the principles of contraposition, conversion, and transitivity. (Author/RC)

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An Exploration of Specific Transfer Properties of Different Instructional Sequences Designed for Use in Teaching Selected Principles of Conditional Logic

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This investigation was designed to ascertain whether students could transfer concepts related to specific rules of conditional logic to two designated areas. Specifically, the first type of transfer investigated was concerned with the ability of students to judge verbal simple deductive arguments written with suggestive content after instruction on judging the same types of arguments written with non-suggestive content. The types of arguments used in this test of transfer dealt with the contrapositive (principle 1), converse (principle 2), and transitive (principle 3) principles of conditional logic. The second type of transfer investigated was the ability of students to judge verbal simple deductive arguments written with familiar content which were examples of the principle of inversion (principle 4), after instruction only on the principles of contraposition, conversion and transitivity.

Personnel and Facilities

The subjects in this study were 94 pre-service elementary school teachers enrolled in four of six sections of Math Ed 420 at The Pennsylvania State University, Spring Term, 1973. These four sections were chosen because computer assisted instruction constituted an integral part of their instruction. The CAI facility used in this study was an IBM 1500 Instructional System consisting of an IBM 1130 computer and 32 remote student stations. Each student station is equipped with a cathode ray tube (CRT), a 16mm image projector, an audio tape system with earphones, and a response system consisting of a light pen capable of sensing lighted areas on the CRT and a modified typewriter keyboard. For this study the audio system and image projector were not used.

Materials

A set of seven behavioral objectives was written which applied to each instructional treatment. Examples of these objectives together with sample criterion performance items follow:

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A. Objective (V,S)

Given: Simple conditional arguments in verbal form (V) involving principle 1,2, or 3.

Required Performance: Select from a set of three choices the one that is a correct translation of the argument into symbolic form, (S).

Criterion: At least 2 out of 3 correct on each of principles 1, 2, and 3.

Sample Criterion Performance Item:

Given the verbal argument

If it rains, then we will not go swimming.

We will not go swimming.

It is raining.

Which one of the following is a correct symbolic translation of the verbal argument?

1)	2)	3)
If A, then B.	If A, then not B.	If A, then not B.
B.	Not B.	Not B.
---	---	---
Not A.	A.	Not A.

B. Objective $(V,S)_4^t$

Given: Simple conditional arguments in verbal form (V) involving principle 4.

Required Performance: Select from a set of three choices the one that is a correct translation of the argument into symbolic form (S).

Criterion: At least 4 out of 5 correct on principle 4.

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Sample Criterion Performance Item:

Given the verbal argument

If this car is Mr. Wilson's, then it is a Ford.

This car is not Mr. Wilson's.

This car is not a Ford.

Which one of the following is a correct symbolic translation of the verbal argument?

1)	2)	3)
If P, then Q.	If P, then Q.	If P, then Q.
P.	Not P.	Not P.
----------	----------	----------
Not Q.	Q.	Not Q.

C. Objective (S,J)

Given: Simple conditional arguments in symbolic form (S) involving principle 1,2, or 3.

Required Performance: Select from a set of three choices the correct validity judgment (J).

Criterion: At least 2 out of 3 correct on each of principles 1, 2, and 3.

Sample Criterion Performance Item:

Suppose you know that

If C. then D.

If D, then not F.

Then would this be true?

If C, then not F.

1) Yes 2) No 3) Maybe

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D. Objective $(S,J)_4^t$

Given: Simple conditional arguments in symbolic form (S) involving principle 4.

Required Performance: Select from a set of three choices the correct validity judgment (J).

Criterion: At least 4 out of 5 correct on principle 4.

Sample Criterion Performance Item:

Suppose you know that

If not A, then B.

A.

Then would this be true?

B.

1) Yes 2) No 3) Maybe

E. Objective (V,J)

Given: Simple conditional arguments in verbal form (V) involving principle 1,2, or 3.

Required Performance: Select from a set of three choices the correct validity judgment (J).

Criterion: At least 2 out of 3 correct on each of principles 1, 2, and 3.

Sample Criterion Performance Item:

Suppose you know that

If the cat is black, then his name is Felix.

The cat's name is not Felix.

Then would this be true?

The cat is not black.

1) Yes 2) No 3) Maybe

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F. Objective $(V,J)_s^t$

Given: Simple conditional arguments in suggestive verbal form (V) involving principle 1,2, or 3.

Required Performance: Select from a set of three choices the correct validity judgment (J).

Criterion: At least 2 out of 3 correct on each of principle 1, 2, and 3.

Sample Criterion Performance Item:

Suppose you know that

If dogs have three legs, then cats cannot fly.

Cats can fly.

Then would this be true?

Dogs do not have three legs.

1) Yes 2) No 3) Maybe

G. Objective $(V,J)_4^t$

Given: Simple conditional arguments in verbal form (V) involving principle 4.

Required Performance: Select from a set of tnree choices the correct validity judgment (J).

Criterion: At least 4 out of 5 correct on principle 4.

Sample Criterion Performance Item:

Suppose you know that

If the coat is brown, it belongs to Jim.

The coat is not brown.

Then would this be true?

The coat belongs to Jim.

1) Yes 2) No 3) Maybe

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Experimental Design

The studeats received instruction only on objectives (V,S) and (S,J). Approximately half of the students interacted with the objectives in the order (V,S), (S,J). For the other students, the order was reversed. Instruction on objective (V,S) consisted of examples of statements and arguments written in verbal and symbolic form. The students were asked to select the correct symbolic form for the given verbal form. If a student selected an incorrect form he was shown the correct form along with explanations of why it was correct.

Venn diagrams were used as a major component of the instruction designed to enable the learner to attain objective (S,J). The student was given a conditional statement in symbolic form and asked to select the correct Venn diagram that represented the statement.

For example, the student was given the conditional statement "If A, then B." He will have had experience interpreting that statement to mean "If $x \in A$, then $x \in B$" (i.e., if x is an element of A, then x is an element of B). The learner was expected to select, from four possibilities, the correct Venn diagram. The four Venn diagrams used for this purpose are shown in Figure 1. If a student did not select the correct Venn diagram, he was shown why his choice was incorrect and then shown the correct choice. An example illustrating how Venn diagrams were used follows.

All arguments have the following format:

Premise
Premise

Conclusion

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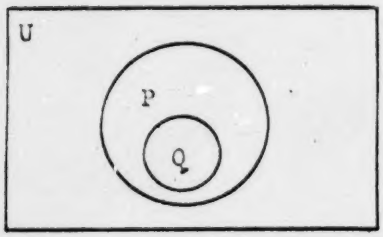
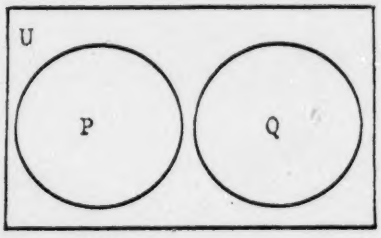
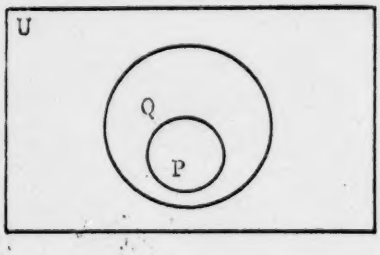


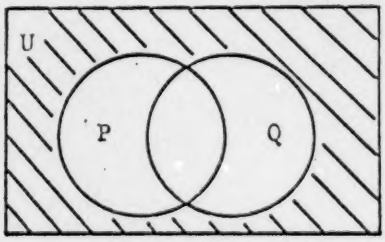
If Q, then P.



If P, then not Q.



If not Q, then not P.



If not P, then Q.

Figure 1. Venn Diagrams Representing Various Conditional Statements

* The shaded portion of the universe in the diagram for "If not P, then Q." indicates that particular part is empty.

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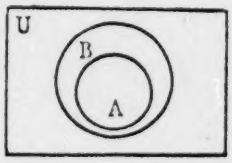
The premises are assumed to be true. A specific example is:

If A, then B.

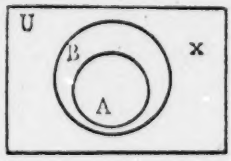
Not B.

Not A.

After the learner selected, or had been given, the Venn diagram that correctly represented the first premise, "If A, then B.", he was told that the second premise places the element x. This is the Venn diagram that represents "If A, then B."



The learner was expected to interpret the second premise to mean "x $\notin$ B" (i.e. x is not an element of B). After a suitable pause, the learner saw the following diagram on the CRT screen and was asked if the conclusion follows.



The possible answers are "Yes," "No," or Maybe." The learner was expected to see that the answer to this example is "Yes."

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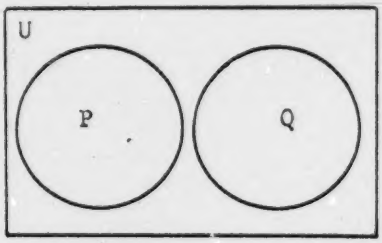
Following is an example with a "Maybe" answer.

If P, then not Q.

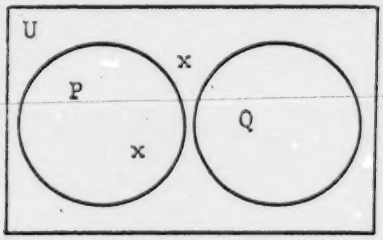
Not Q.

Not P.

The Venn diagram representing the first premise is:



The second premise is interpreted as "x $\notin$ Q." The learner was shown the following diagram, with a suitable explanation and asked if the conclusion follows.



Feedback to answers may include why an answer is incorrect as well as why an answer is correct.

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The model for testing the hypotheses was a pretest-instruction-posttest design. Students who failed the pretest on objective (V,J) were randomly assigned to either the (V,S) - (S,J) sequence or the (S,J) - (V,J) sequence. When the students in each segment completed the second instruction treatment, approximately half were randomly assigned to receive a guided thinking information (GTI) episode. This episode consisted of statements informing the students that they had acquired the necessary prerequisite behaviors and to apply them when taking the following test. No practice was given in this episode. In all there were four instructional treatments; (V,S) - (S,J) - GTI, (V,S) - (S,J), (S,J) - (V,S) - GTI, and (S,J) - (V,S). See Figure 1.

Measuring Achievements

The criterion tests for objectives (V,J), $(V,J)_s^t$, (V,S) and (S,J) each consisted of nine items, three items on each of principles 1,2, and 3. In order to reach criterion a student had to get at least two out of three correct on each principle. The criterion tests for objectives $(V,S)_4^t$ and $(S,J)_4^t$ each consisted of five items. Pass criterion was at least four out of five correct.

The nine examples for the (V,J) objective were randomized and given before the fourteen items on the $(V,J)_s^t$ and $(V,J)_4^t$ tests which were combined and randomized. The fourteen items on the test for (V,S) and $(V,S)_4^t$ were combined and randomized as were the fourteen items on the test for (S,J) and $(S,J)_4^t$.

Data Analysis

Since the possibility existed that the size of the groups traversing each instructional sequence could be small, nonparametric statistics were used to analize the data. The Fisher Exact Probability Test was used to compare groups in different sequences. The Binomial Probability Test was used to compare groups

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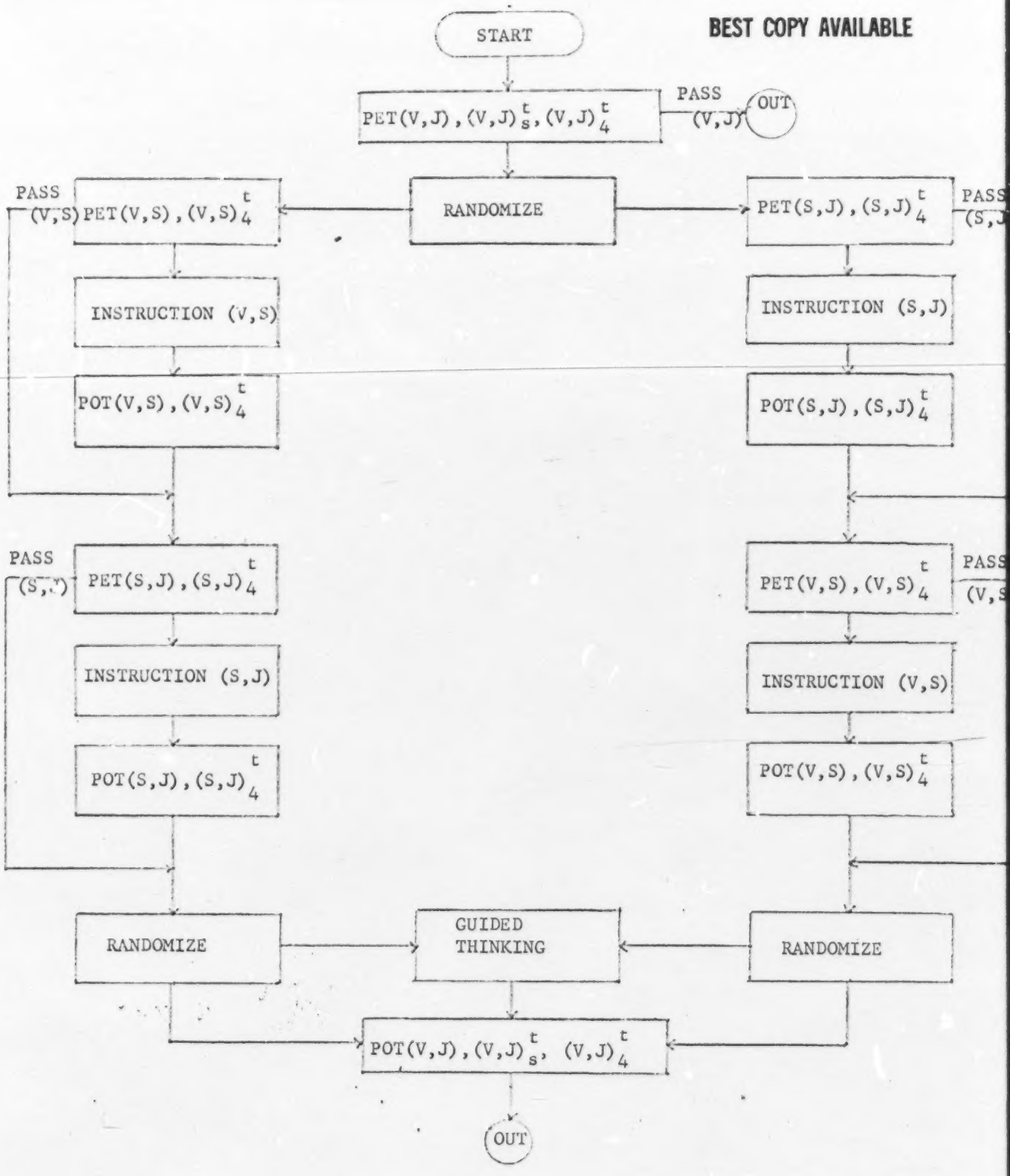

Figure 1

Modified Flow Chart of Instructional Sequences

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within the same sequence. Unless specified otherwise an α=.20 was used in the tests.

This investigation attempted to answer four general questions.

G1. Is there any difference between the proportions of students in each of the four sequences who demonstrate mastery of the terminal behaviors (V,J), $(V,J)^t_s$, and $(V,J)^t_4$ after demonstrating mastery of each objective (V,S) and (S,J) following instruction on at least objective (S,J)?

G2. Does instruction to criterion on a subcompetency objective imply mastery of the subcompetency transfer objective?

G3. Does demonstrating mastery of each objective (V,S) and (S,J) following instruction on at least objective (S,J) and demonstrating mastery of objective (V,J) imply mastery of the principle transfer objective $(V,J)^t_4$?

G4. Does demonstrating mastery of each objective (V,S) and (S,J) following instruction on at least objective (S,J) and demonstrating mastery of objective (V,J) imply mastery of the content transfer objective $(V,J)^t_s$.

Twenty two specific hypotheses were generated by these general questions.

Interpretations of Outcomes

From the analysis of the data none of the four instructional sequences can be recommended to assure that a significant number, 80 percent, of students will be able to demonstrate the ability to transfer acquired concepts to both suggestive content and to the principle of inversion. Of the students in the (V,S) - (S,J) - GTI group who demonstrated mastery of both enabling objectives and had instruction on objective (S,J), a significantly smaller proportion of them demonstrated mastery of objectives (V,J), $(V,J)^t_s$ and $(V,J)^t_4$ than did students in the (V,S) - (S,J) sequence. Since the only observable difference between these two sequences is the guided thinking information included in the (V,S) - (S,J) - GTI, one might be tempted to conclude that the guided thinking information interfered with transfer.

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This author believes this conclusion may not be warranted because one of the groups contained only four students who staisfied the required conditions to be included in this test. Strengthening the author's point of view is the fact that there was no significant difference between the (S,J) - (V,S) - GTI group and the (S,J) - (V,S) group.

Another group of hypotheses was evaluated in order to determine if instruction to criterion on subcompetency objective (S,J) implies mastery of transfer objective $(S,J)^{t}_{4}$. That is, if students can demonstrate mastery of judging simple deductive arguments written in symbolic form that are examples of principles 1,2, and 3, can they demonstrate mastery of principle 4? This information is summarized in Table 1.

Table 1

Information Used in Evaluating Transfer from (S,J) to $(S,J)^{t}_{4}$.

Treatment Group	N	Smallest X needed to retain hypothesis	X	Probability	Decision
(S,J), (V,S) and (S,J), (V,S), GTI	17	12	8	0.0026	Reject
(V,S), (S,J) and (V,S), (S,J), GTI	13	9	8	0.0998	Reject

Since the table indicates that in each sequence significantly fewer than 80 percent of the students could demonstrate mastery of principle 4, one must conclude that instruction to criterion on objective (S,J) was not sufficient to insure transfer to objective $(S,J)^{t}_{4}$.

Information concerning hypotheses that if students demonstrated mastery of subcompetencies (V,S) and (S,J) after instruction on at least (S,J) and after

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demonstrating mastery of principles 1,2, and 3 on posttest (V,J), they would demonstrate mastery of the same principles written in suggestive form on posttest $(V,J)_s^t$ or demonstrate mastery of principle 4 is summarized in Table 2. In order for an hypothesis to be rejected the percent of students demonstrating mastery of the transfer objective must be significantly less than 80.

Table 2

Information Used to Evaluate Transfer to $(V,J)_s^t$ or $(V,J)_4^t$ on Posttest

Treatment Group	Transfer to	N	Smallest X needed to retain Hypothesis	X	Probability	Decision
(V,S), (S,J)	$(V,J)_4^t$	2				No test
(V,S), (S,J), GTI	$(V,J)_4^t$	4	3	2	0.1808	Reject
(S,J), (V,S)	$(V,J)_4^t$	3	2	2	0.4880	Retain
(S,J), (V,S), GTI	$(V,J)_4^t$	5	3	2	0.0579	Reject
(V,S), (S,J)	$(V,J)_s^t$	2				No test
(V,S), (S,J), GTI	$(V,J)_s^t$	4	3	2	0.1808	Reject
(S,J), (V,S)	$(V,J)_s^t$	5	3	5	1.0000	Retain
(S,J), (V,S), GTI	$(V,J)_s^t$	5	3	4	0.6723	Retain

The information contained in Table 2 indicates that transfer to principle 4 and to the suggestive domain was evidenced in the (S,J) - (V,S) sequence. Transfer to the suggestive domain was evidenced in the (S,J) - (V,S) - GTI sequence.

Although a trend seems to favor the (S,J) - (V,S) sequences, conclusions drawn from such small samples are tenuous at best. Further investigations into these areas were made in the post hoc analysis.

Post Hoc Analysis

An assessment of the effects of the guided thinking information seems to

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indicate that it neither consistently strengthened nor weakened the student's ability to correctly judge verbal simple deductive arguments in conditional logic. It seems justified to combine the (V,S) - (S,J) and (V,S) - (S,J) - GTI groups and the (S,J) - (V,S) and (S,J) - (V,S) - GTI groups in an effort to determine in what order the students should interact with the enabling objectives in order to facilitate transfer.

Considering the two sequences (V,S) - (S,J) and (S,J) - (V,S) the Binomial test with $p = .50$ was used to determine if transfer did occur. The results of these tests are given in Table 3.

It should be noted that in order for a student to be included in these tests he must have had instruction on objective (S,J) and demonstrated mastery of both objectives (V,S) and (S,J). It was not necessary for a student to demonstrate mastery of objective (V,J), neither was the instructional adequacy of the (S,J) episode considered.

Table 3 indicates that with the fallacy principles of conversion and inversion a noticeable proportion of students in both sequences failed the pretest and passed the posttest. The four probabilities range from approximately .01 to .04. After instruction on at least objective (S,J) students in both sequences seemed to show significant improvement in their ability to judge examples of the principle of conversion written with suggestive content. Likewise, the students in both sequences evidenced significant improvement in their ability to judge examples of the principle of inversion written with familiar content although they had received no instruction on this principle. It appears that it may be possible to give adequate instruction on the three principles of contraposition, conversion and transitivity and, as a result, students will be able to demonstrate mastery of the principle of inversion.

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Table 3

Summary of Tests for Significance of Changes for Students Who Had Instruction on Objective (S,J) and demonstrated Mastery of Objective (V,S) and (S,J).

	Principle - Content	Order of Objectives	Pretest	Posttest Fail	Posttest Pass	Result p
1	Contrapositive - Suggestive	(V,S), (S,J)	Pass	3	8	1.0000
			Fail	1	2	
2	Converse - Suggestive	(V,S), (S,J)	Pass	1	0	.0117
			Fail	3	10	
3	Transitive - Suggestive	(V,S), (S,J)	Pass	1	10	1.0000
			Fail	1	2	
4	Inverse - Familiar	(V,S), (S,J)	Pass	0	2	.0312
			Fail	6	6	

Table 3

Continued

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	Principle - Content	Order of Objectives	Pretest	Posttest Fail	Posttest Pass	Result p
1	Contrapositive - Suggestive	(S,J), (V,S)	Pass	3	12	.5078
			Fail	0	6	
2	Converse - Suggestive	(S,J), (V,S)	Pass	2	4	.0386
			Fail	5	10	
3	Transitive - Suggestive	(S,J), (V,S)	Pass	0	19	.5000
			Fail	0	2	
4	Inverse - Familiar	(S,J), (V,S)	Pass	0	6	.0312
			Fail	9	6	

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While students in both sequences can show improvement in the fallacy principles neither sequence appears to enable students to show noticeable improvement in the other principles. A reason for this may be that a large percentage of students in each sequence demonstrated mastery on both the pretest and the posttest for the principles of contraposition and transitivity. These ranged from 57 to 90 percent.

The trend of demonstrating mastery on both the pretests and posttests for the principles of contraposition and transitivity in the suggestive domain was true for students in general. Of students in the (V,S), (S,J) sequences who had instruction on objective (S,J), approximately 55 percent demonstrated mastery of the contrapositive principle in the suggestive domain and 68 percent demonstrated mastery of the transitive principle in the suggestive domain on both the pretest and the posttest. Of students in the (S,J),(V,S) sequences the corresponding percentages were 60 and 81 respectively. This information is summarized in Table 4.

Testing a post-hoc hypothesis that these proportions are equal (Glass and Stanley, p. 326) yields a probability less than .02 for each sequence on a two-tailed test.

Information concerning the results of using this test with each sequence on the posttest is given in Table 5. As the table indicates, the transitive-suggestive items were easier for the students than were the transitive-familiar items.

Similar evaluations were made on the same population on the pretest. For all students combined the transitive suggestive items were easier than the transitive familiar items ($p < .01$) and there was no difference in difficulty of the familiar and suggestive items on the principles of contraposition and conversion ($p > .40$).

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Table 4

Percent of Mastery on Pretest/Posttest for Students Who Had Instruction on Objective (S,J).

Principle - Content	Order of Objectives (V,S), (S,J)		(S,J), (V,S)	
	PET and POT	POT (n = 31)	PET and POT	POT (n = 42)
1 Contrapositive - Familiar	58	84	67	82
2 Converse - Familiar	13	39	12	45
3 Transitive - Familiar	26	48	40	69
4 Inverse - Familiar	10	35	19	36
1 Contrapositive - Suggestive	55	71	60	82
2 Converse - Suggestive	0	39	10	38
3 Transitive - Suggestive	68	77	81	93

Table 5

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Information concerning evaluation of hypotheses that the proportion of students reaching criterion on a principle in the familiar domain is equal to the proportion of students reaching criterion on the same principle in the suggestive domain.

Posttest $(V,J)^{t}_{s}, (V,\bar{J})$

Principle	Sequence	Content: Familiar	Suggestive: Fail	Suggestive: Pass	Result
1	(S,J), (V,S)	Pass	7	14	$p > .78$
		Fail	15	6	
1	(V,S), (S,J)	Pass	4	8	No test
		Fail	16	3	
2	(S,J), (V,S)	Pass	3	10	No test
		Fail	28	1	
2	(V,S), (S,J)	Pass	0	5	No test
		Fail	25	1	
3	(S,J), (V,S)	Pass	3	14	$p < .02$
		Fail	9	16	
3	(V,S), (S,J)	Pass	3	4	$p < .06$
		Fail	14	10	

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Summary

The results of this investigation coincide with the results of a concurrent investigation by Shipman. Within the stated parameters of this study there is a trend indicating that students should interact with the objectives in the order (S,J) - (V,S) rather than (V,S) - (S,J). That is, they should be introduced to the symbolic form of a simple conditional argument and learn how to judge them before translating arguments from verbal to symbolic form.

The guided thinking information (GTI) episode used in this study apparently neither helped nor hindered the learning process.

The data indicates that after instruction in judging simple conditional arguments written in symbolic form embodying the contrapositive, converse or transitive principles students can transfer acquired concepts and demonstrate improvement in their ability to judge arguments written with suggestive content embodying the converse principle. They can also transfer acquired concepts and demonstrate improvement in their ability to judge arguments written with familiar content embodying the inverse principle, although they received no instruction on this principle. A reason that significant transfer to the contrapositive and transitive principles written with suggestive content was not observed may be attributed to the fact that a majority of students demonstrated mastery on both the pretest and the posttest for these principles.

It is interesting to note that for the contrapositive and converse principles suggestive content appeared to be as easy for the students as familiar content. For the transitive principle the suggestive content was easier for the students than the familiar content. The reason for this is difficult to explain. It may be that when the content becomes "too suggestive" students concentrate more on the logical form of the argument.